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Toxicological Profile for

CHROMIUM

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

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TOXICOLOGICAL PROFILE FOR CHROMIUM

Prepared by:

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Under Subcontract to:

Clement International Corporation
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UPDATE STATEMENT

A Toxicological Profile for Chromium was released on July 1989. This edition supersedes any previously released draft or final profile.

Toxicological profiles are revised and republished as necessary, but no less than once every three years. For information regarding the update status of previously released profiles contact ATSDR at:

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1. PUBLIC HEALTH STATEMENT

This Statement was prepared to give you information about chromium and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1,300 sites on its National Priorities List (NPL). Chromium in its oxidized form has been found in at least 115 of these sites. However, we do not know how many of the 1,300 NPL sites have been evaluated for hexavalent chromium. As EPA evaluates more sites, the number of sites at which hexavalent chromium is found may change. This information is important for you to know because the hexavalent form of chromium may cause harmful health effects and because these sites are potential or actual sources of human exposure to hexavalent chromium.

When a chemical is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to chromium or chromium compounds, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, lifestyle, and state of health.

1.1 WHAT IS CHROMIUM?

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium is present in the environment in several different forms. The most common forms are chromium(0), trivalent [or chromium(III)], and hexavalent [or chromium(VI)]. Chromium(III) occurs naturally in the environment and is an essential nutrient required by the human body to promote the action of insulin in body tissues so that sugar, protein, and fat can be used by the body. Chromium(VI) and chromium(0) are generally produced by industrial processes. No known taste or odor is associated with chromium compounds. The metal chromium, which is the chromium(0) form, is a steel-gray solid with a high melting point. It is used mainly for making steel and other alloys. The naturally occurring mineral chromite in the chromium(III) form is used as brick lining for high-temperature industrial furnaces, for making metals and alloys (mixtures of metals), and chemical compounds. Chromium compounds, mostly in chromium(III) or chromium(VI) forms, produced by the chemical industry are used for chrome plating, the manufacture of dyes and

pigments, leather tanning, and wood preserving. Smaller amounts are used in drilling muds, rust and corrosion inhibitors, textiles, and toner for copying machines. For more information on the physical and chemical properties and on the production and use of chromium, see Chapters 3 and 4.

1.2 WHAT HAPPENS TO CHROMIUM WHEN IT ENTERS THE ENVIRONMENT?

Chromium enters the air, water, and soil mostly in the chromium(III) and chromium(VI) forms as a result of natural processes and human activities. Emissions from burning coal and oil, and steel production can increase chromium(III) levels in air. Stainless steel welding, chemical manufacturing, and use of compounds containing chromium(VI) can increase chromium(VI) levels in air. Waste streams from electroplating can discharge chromium(VI). Leather tanning and textile industries as well as those that make dyes and pigments can discharge both chromium(III) and chromium(VI) into waterways. The levels of both chromium(III) and chromium(VI) in soil increase mainly from disposal of commercial products containing chromium, chromium waste from industry, and coal ash from electric utilities.

In air, chromium compounds are present mostly as fine dust particles. This dust eventually settles over land and water. Rain and snow help remove chromium from air. Chromium compounds will usually remain in the air for less than 10 days. Although most of the chromium in water binds to dirt and other materials and settles to the bottom, a small amount may dissolve in the water. Soluble chromium compounds can remain in water for years before settling to the bottom. Fish do not accumulate much chromium in their bodies from water. Most of the chromium in soil does not dissolve easily in water and can attach strongly to the soil. A very small amount of the chromium in soil, however, will dissolve in water and can move deeper in the soil to underground water. The movement of chromium in soil depends on the type and condition of the soil and other environmental factors. For more information about the fate and movement of chromium compounds in the environment, see Chapters 4 and 5.

1.3 HOW MIGHT I BE EXPOSED TO CHROMIUM?

You can be exposed to chromium by breathing air, drinking water, or eating food containing chromium or through skin contact with chromium or chromium compounds. The level of chromium in air and water is generally low. The concentration of total chromium in air [both chromium(III) and chromium(VI)] generally ranges between 0.01 and 0.03 microgram (µg) (1 µg equals 1/1,000,000 of a gram) per cubic meter of air (µg/m^3). Chromium concentrations in drinking water [mostly as chromium(III)] are generally very low, less than 2 parts of chromium in a billion parts of water (2 ppb). Contaminated well water may contain chromium(VI). For the general population, eating foods that contain chromium is the most

likely route of chromium exposure. Chromium(III) occurs naturally in many fresh vegetables, fruits, meat, yeast, and grain. Various methods of processing, storage, and preparation can alter the chromium content of food. Acidic foods in contact with stainless steel cans or cooking utensils might contain higher levels of chromium because of leaching from stainless steel. Refining processes used to make white bread or sugar can decrease chromium levels. Chromium(III) is an essential nutrient for humans. On the average, adults in the United States take in an estimated 60 µg of chromium daily from food. You may also be exposed to chromium from using consumer products such as household utensils, wood preservatives, cement, cleaning products, textiles, and tanned leather.

People who work in industries that process or use chromium or chromium compounds can be exposed to higher-than-normal levels of chromium. An estimated 305,000 workers in the United States are potentially exposed to chromium and chromium-containing compounds in the workplace.

Occupational sources of chromium exposure (with chemical forms of interest shown in parentheses) may occur in the following industries:

- Stainless steel welding [chromium(VI)]
- Chromate production [chromium(VI)]
- Chrome plating [chromium(VI)]
- Ferrochrome industry [chromium(III) and chromium(VI)]
- Chrome pigments [chromium(III) and chromium(VI)]
- Leather tanning [mostly chromium(III)]

Examples of other occupations that may involve chromium exposure include:

- Painters [chromium(III) and chromium(VI)]
- Workers involved in the maintenance and servicing of copying machines, and the disposal of some toner powders from copying machines [chromium(VI)]
- Battery makers [chromium(VI)]
- Candle makers [chromium(III) and chromium(VI)]
- Dye makers [chromium(III)]
- Printers [chromium(III) and chromium(VI)]
- Rubber makers [chromium(III) and chromium(VI)]
- Cement workers [chromium(III) and chromium(VI)]

A list of other industries that may be sources of occupational exposure is given in Section 5.5.

You may be exposed to higher-than-normal levels of chromium if you live near the following:

- Landfill sites with chromium-containing wastes
- Industrial facilities that manufacture or use chromium and chromium-containing compounds
- Cement-producing plants, because cement contains chromium
- Industrial cooling towers that use chromium as rust inhibitors
- Waterways that receive industrial discharges from electroplating, leather tanning, and textile industries
- Busy roadways, because emissions from automobile brake lining and catalytic converters contain chromium

In addition, you may be exposed to higher levels of chromium if you use tobacco products, since tobacco contains chromium. For additional information about chromium exposure, see Chapter 5.

1.4 HOW CAN CHROMIUM ENTER AND LEAVE MY BODY?

Chromium can enter your body when you breathe air, eat food, or drink water containing chromium. Chromium(VI) enters the body more easily than chromium(III), but once inside the body, chromium(VI) is changed to chromium(III). When you breathe air containing chromium, chromium particles can be deposited in the lungs. Particles that are deposited in the upper part of the lungs are likely to be coughed up and swallowed. Particles deposited deep in the lungs are likely to remain long enough for some of the chromium to pass through the lining of the lungs and enter your bloodstream. Once in the bloodstream, chromium is distributed to all parts of the body, then will pass through the kidneys, and be eliminated in the urine within a few days. Everyone normally eats or drinks a small amount of chromium daily. Most of the chromium that you swallow leaves your body within a few days through the feces and never enters your blood. A small amount (about 0.4% to 2.1%) will pass through the lining of the intestines and enter the bloodstream. Once in the bloodstream, chromium is distributed to all parts of the body where it is used to carry out essential functions. Chromium will then pass through the kidneys and be eliminated in the urine in a few days. Chromium(III) present in food can attach to other compounds that make it easier for chromium to enter your bloodstream from your stomach and intestines. This form of chromium is used by your body to carry out essential body functions. If your skin comes into contact with chromium, very little will enter your body unless your skin is damaged. For more information, please read Chapter 2.

1.5 HOW CAN CHROMIUM AFFECT MY HEALTH?

Chromium(III) is an essential nutrient that helps the body use sugar, protein, and fat. An intake of 50 to 200 µg of chromium(III) per day is recommended for adults. On the average, adults in the United States take in an estimated 60 µg of chromium per day in food. Therefore, most people in the United States take in enough chromium(III) in the food they eat, but some people's diets may not provide enough chromium(III). Without chromium(III) in the diet, the body loses its ability to use sugars, proteins, and fat properly, which may result in weight loss or decreased growth, improper function of the nervous system, and a diabetic-like condition.

The health effects resulting from exposure to chromium(III) and chromium(VI) are fairly well described in the literature. Breathing in high levels (greater than 2 $\mu g/m^3$) of chromium(VI) can cause irritation to the nose, such as, runny nose, sneezing, itching, nosebleeds, ulcers, and holes in the nasal septum. These effects have primarily occurred in factory workers who make or use chromium(VI) for several months to many years. Long-term exposure to chromium has been associated with lung cancer in workers exposed to levels in air that were 100 to 1,000 times higher than those found in the natural environment. Lung cancer may occur long after exposure to chromium has ended. It is not clear which form(s) of chromium is capable of causing lung cancer in workers. Chromium(VI) is believed to be primarily responsible for the increased lung cancer rates observed in workers who were exposed to high levels of chromium in workroom air. Breathing in small amounts of chromium(VI) for short or long periods does not cause a problem in most people. However, high levels of chromium in the workplace have caused asthma attacks in people who are allergic to chromium. Breathing in chromium(III) does not cause irritation to the nose or mouth in most people. In the same way, small amounts of chromium(VI) that you swallow will not hurt you; however, accidental or intentional swallowing of larger amounts have caused stomach upsets and ulcers, convulsions, kidney and liver damage, and even death. The levels of chromium(VI) that caused these effects are far greater than those that you might be exposed to in food or water. Although chromium(III) in small amounts is an important nutrient needed by the body, swallowing large amounts of chromium(III) may cause health problems. Workers handling liquids or solids that have chromium(VI) in them have developed skin ulcers. Some people have been found to be extremely sensitive to chromium(VI) or chromium(III). Allergic reactions consisting of severe redness and swelling of the skin have been noted. Exposure to chromium(III) is less likely than exposure to chromium(VI) to cause skin rashes in chromium-sensitive people. The metal, chromium(0), is less common, and we do not know much about how it affects your health. We have no reliable information that any form of chromium has harmful effects on reproduction or causes birth defects in humans.

In animals that breathed high levels of chromium, harmful effects on the respiratory system and a lower ability to fight disease were noted. However, we do not know if similar effects

could occur in humans or if chromium can lower a person's ability to fight disease. Some of the female mice that were given chromium(VI) by mouth had fewer offspring and had offspring with birth defects. Some male mice that were given chromium(VI) or chromium(III) by mouth had decreased numbers of sperm in the testes. The birth defects or the decrease in sperm occurred in mice at levels about several thousand times higher than the normal daily intake by humans. Some chromium(VI) compounds produced lung cancer in animals that breathed in the particles or had the particles placed directly in their lungs. In animals that were injected with some chromium(VI) compounds, tumors formed at the site of injection.

Because some chromium(VI) compounds have been associated with lung cancer in workers and caused cancer in animals, the Department of Health and Human Services has determined that certain chromium(VI) compounds (calcium chromate, chromium trioxide, lead chromate, sodium dichromate, strontium chromate, and zinc chromate) are known carcinogens. The International Agency for Research on Cancer (IARC) has determined that chromium(VI) is carcinogenic to humans, based on sufficient evidence in humans for the carcinogenicity of chromium(VI) compounds as found in chromate production, chromate pigment production, and chromium plating industries. IARC's determination is also based on sufficient evidence in experimental animals for the carcinogenicity of calcium chromate, zinc chromate, strontium chromate, and lead chromate; and limited evidence in experimental animals for the carcinogenicity of chromium acid and sodium dichromate. IARC has also determined that chromium(0) and chromium(III) compounds are not classifiable as to their carcinogenicity to humans.

For more information on the health effects of chromium, please see Chapter 2.

1.6 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO CHROMIUM?

Chromium can be measured in the hair, urine, serum, red blood cells, and whole blood. However, since chromium(III) is an essential nutrient, low levels of chromium are normally found in body tissues and urine. Tests for chromium exposure are most useful for people exposed to high levels. These tests cannot determine the exact levels of chromium you may have been exposed to or predict whether or not health effects will occur. High chromium levels in the urine and red blood cells indicate exposure to chromium(VI) or chromium(III) compounds. Since the body changes chromium(VI) to chromium(III), the form of chromium that you were exposed to cannot be determined from levels in the urine. Much more chromium(VI) can enter red blood cells than chromium(III), but chromium(VI) can be changed to chromium(III) within these cells. Therefore, chromium levels in the red blood cells probably indicate exposure to chromium(VI). Because red blood cells last about 120 days before they are replaced by newly made red blood cells, the presence of chromium in red blood cells can show whether a person was exposed to chromium 120 days prior to testing

but not if exposure occurred longer than 120 days before testing. Skin patch tests may indicate whether a person is allergic to chromium. For more information, please see Chapters 2 and 6.

1.7 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

EPA has set the maximum level of chromium(III) and chromium(VI) allowed in drinking water at 100 µg chromium/L. According to the EPA, the following levels of chromium(III) and chromium(VI) in drinking water are not expected to cause effects that are harmful to health: 1,400 µg chromium/L for 10 days of exposure for children, 240 µg chromium/L for longer-term exposure for children, 840 µg chromium/L for longer-term exposure for adults, and 120 µg chromium/L for lifetime exposure of adults.

The Occupational Safety and Health Administration (OSHA) regulates chromium levels in the workplace air. The occupational exposure limits for an 8-hour workday, 40-hour workweek are 500 µg chromium/m^3 for water-soluble chromic [chromium(III)] or chromous [chromium(II)] salts and 1,000 µg chromium/m^3 for metallic chromium [chromium(0)], and insoluble salts. The level of chromic acid and chromium(VI) compounds in the workplace air should not be higher than 100 µg chromium(VI)/m^3 for any period of time.

For chromium(0), chromium(II), and chromium(III), the National Institute for Occupational Safety and Health (NIOSH) recommends an exposure limit of 500 µg chromium(VI)/m^3 for a 10-hour workday, 40-hour workweek. NIOSH considers all chromium(VI) compounds (including chromic acid) to be potential occupational carcinogens and recommends an exposure limit of 1 µg/m^3 for a 10-hour workday, 40-hour workweek.

For more information, please see Chapter 7.

1.8 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, E-29
Atlanta, Georgia 30333
(404) 639-6000

This agency can also provide you with information on the location of the nearest occupational and environmental health clinic. These clinics specialize in the recognition, evaluation, and treatment of illnesses resulting from exposure to hazardous substances.